

## Radiographic Study of the Broadbeach Aboriginal Dentition

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**ABSTRACT** This study forms part of a larger anthropological investigation of the Ngaraangbal Aboriginal Tribe's ancestral burial ground at Broadbeach, Australia. It examines the dentition, records the associated pathology in a noninvasive manner, and relates this to the likely subsistence diet of the tribe. The Broadbeach osteological collection was returned for reburial in 1985; however, radiographic and photographic records of 36 adult males were available. These form the basis of our study. The pathology noted in the study sample was compared with a representative sample ( $n = 38$ ) of pre-European Aboriginal remains from throughout Queensland for verification purposes only. Rates of dental pathology and injury were calculated from the radiographic and photographic records. There was a significant rate of tooth-wear related intra-bony pathology (4.0%), moderate to severe alveolar bone loss, and heavy dental attrition, of which the mandibular posterior teeth were the most severely affected. Caries prevalence (0.8%) was low for hunter-gatherer populations. A large number of molar pulp chambers had a distinctive "cruciate" morphology resulting from the formation of secondary dentine and pulp stones. Injuries and abnormalities included upper central incisor avulsion (58.3%) and taurodontism. These results support the proposal that the Ngaraangbal tribe was a hunter-gatherer population subsisting on an abrasive diet that included marine foods. *Am J Phys Anthropol* 107:211-219, 1998. © 1998 Wiley-Liss, Inc.

The Broadbeach Aboriginal burial ground was excavated on the Gold Coast, Queensland, by Laila Haglund and W.B. Wood during 1965-1967. An excavation report (Haglund, 1976) and several skeletal studies (Wood, 1968; Freedman and Wood, 1977; Smith et al., 1981; Hobson and Collier, 1984) provide detailed features of the Broadbeach skeletal collection.

In summary, a total of approximately 150 individual skeletons were recovered over the 3-year excavation period, with approximately 58% regarded as juvenile (less than 20 years old). A total of 64 adult crania were represented in the collection, but sex could be determined in only 58 using both cranial and

associated postcranial criteria (Larnach and Freedman, 1964; Davivongs, 1963a,b; Van Dongen, 1963). Of these, only six were female and the remaining 52 were male. This cemetery population, therefore, was biased strongly in favour of adult males and juveniles, with adult females poorly represented.

Only 41 maxillae and mandibles (36 male and 5 female) were associated with the adult crania. These formed the basis of the metrical study of the crania and mandibles car-

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ried out by Freedman and Wood (1977). At that time, the maxillae and mandibles were photographed and radiographed as part of the general recording of the Broadbeach collection. Prior to the present study, the dental pathology of this largely precontact Aboriginal population had not been addressed.

In 1985, the Broadbeach skeletal collection was claimed for repatriation and reburial by the Kombumerri clan of the Ngara-ngbal people, who are direct descendants of the Broadbeach Aboriginal population. The remains were reburied in 1987.

Carbon dating indicates that the Broadbeach burial ground was in active use from 750 AD to approximately 1900 AD, just after European settlement in the area (Haglund, 1968, 1976). Reports on the proportion of marine food in the diet of this population have been equivocal. Haglund (1976) states that the diet had only a small marine supplement, but Hobson and Collier (1984) proposed that the population was dependent on marine resources.

A number of recent studies in several countries have attempted to correlate the patterns of dental pathology with the diet of precontact indigenous populations (Hall et al., 1986; Jurmain, 1990; Littleton and Frohlich, 1993; Sealy et al., 1992). The composition of prehistoric diets can be determined by the utilization of stable carbon isotope ratios in bones, as used by Hobson and Collier (1984). However, this method of determining the proportion of marine food in the diet can produce results which conflict with the outcomes of traditional studies, as dietary supplements cannot be distinguished from the staple composition of the diet (Sealy et al., 1992).

The aim of the present study, therefore, was to examine the dentition of all adult aboriginal males that had been radiographed and photographed and to detail both dental and bony pathology. Reference to previous literature should then allow a qualified statement on whether the diet was marine-based or contained a marine supplement.

## MATERIALS AND METHODS

The dental condition of the Broadbeach population was determined from the radio-

graphic, photographic, and written records of 36 adult male individuals. The maxillae and mandibles of 38 additional adult male aboriginal individuals from Queensland collections were radiographed and studied for comparison with and verification of the pathology or abnormalities observed in the Broadbeach collection. The comparative group originated from scattered locations throughout Queensland.

The approximate age of all specimens was estimated using the morphology of the pubic symphysis and state of epiphysial fusion (McKern and Stewart, 1957), dental attrition (Brothwell, 1963), and the presence of vertebral arthritis (Stewart, 1958). Based on these criteria, only two specimens could be regarded as elderly. The remainder were estimated to be young to middle-aged adult males. All jaws had been radiographed from three directions: postero-anterior for the anterior jaw segment, and postero-lateral for both posterior segments.

All pathology and other abnormalities observed in both the Broadbeach and the comparative Queensland groups were recorded. Dental attrition was scored as one of eight levels using the method of Molnar (1971). This could be applied to radiographic images with relatively little error (0.23 of a scored unit overestimated on average by reference to the comparative Queensland group). While interproximal wear was considered, no statistical analysis was conducted, as measurement of interproximal wear could not be made accurately due to lateral radiographic overlap. Rates of caries incidence, intra-bony radiolucencies (commonly referred to as periapical pathology), and antemortem tooth loss (AMTL) were calculated. Where it was possible to measure apparent alveolar bone loss, a measurement was recorded. The loss of alveolar bone crestal height was measured from the cemento-enamel junction of the teeth to the crest of the alveolar bone. A correction for both continuous eruption and natural crest height was made.

The measured features were distributed according to both tooth type and position and were analysed for significance using a Chi-square test.

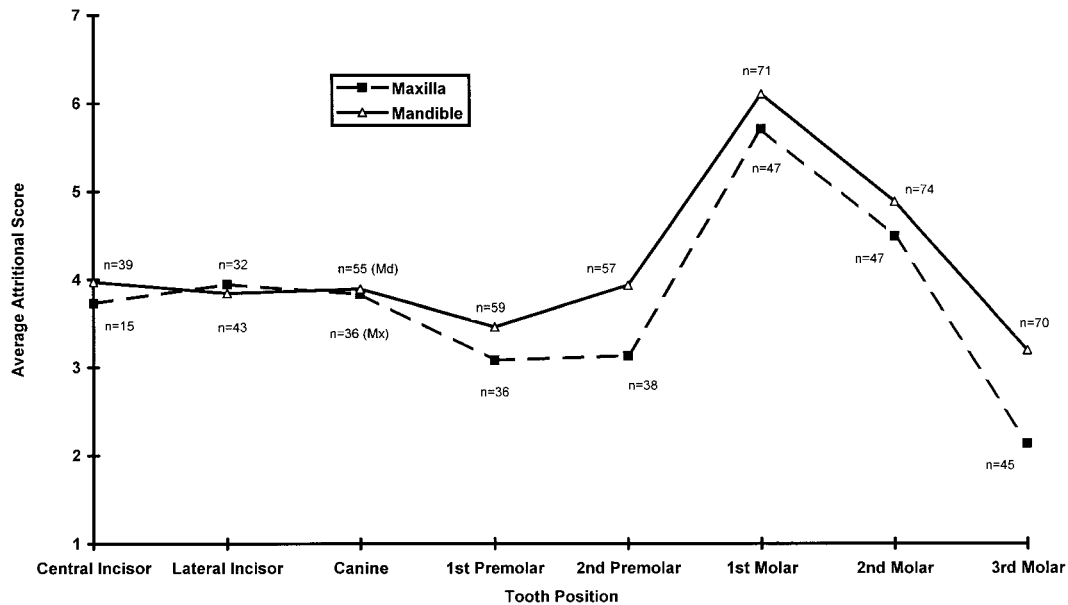


Fig. 1. Average attritional scores in the maxillary and mandibular dentitions of the Broadbeach adult male Aborigines (n = sample number).

## RESULTS

### Attrition

Tooth attrition in the Broadbeach sample was moderately heavy, with the majority of incisors, canines, and premolars showing exposed secondary dentine on the incisal and occlusal surfaces. The molars showed large areas of exposed occlusal secondary dentine. In nearly all cases, at least 7 mm of the anatomical crown remained above the crest of the alveolus on at least one point on each tooth.

The heaviest dental attrition was apparent on the molars in both the maxilla and mandible, of which the mandibular molars were significantly ( $P < 0.05$ ) more worn than the maxillary molars. Attritional gradients in the maxillary and mandibular dentitions are shown in Figure 1.

A characteristic pattern of occlusal concavity or scooping was present on many mandibular molars (Fig. 2). This involved mainly the first and second molars with a marked increase in wear from the mesial to the distal surface, often resulting in a wedge-shaped crown profile. As far as could be determined, this was associated with a reciprocal pattern in the maxilla, although the

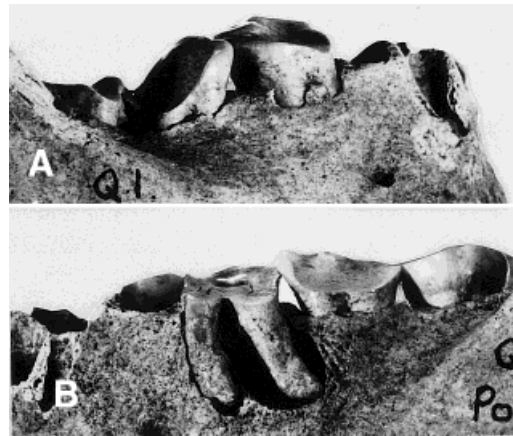


Fig. 2. Molar scooping was seen most commonly in the mandible, generally on the first and second molars.

degree of wear seemed much less, resulting in a less steep gradient. There was no asymmetry associated with this pattern. Statistical analyses were not undertaken for this pattern.

### Periapical pathology

Intra-bony radiolucencies were recorded under the general term of "periapical pathol-

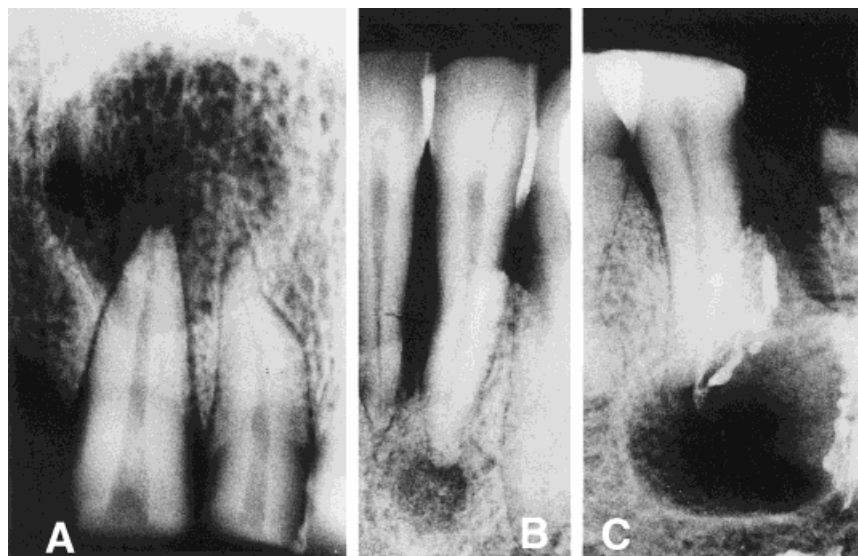


Fig. 3. Periapical radiolucencies of varying size were observed in the Broadbeach group. These ranged from poorly defined unilocular radiolucencies (A) to more discrete areas with a sclerotic margin (B,C).

ogy," as the exact pathological process cannot be determined from radiographs alone. Notwithstanding this, the often large size of the areas and the smooth outline suggests a slowly enlarging lesion, most likely cystic rather than an active osteomyelitic process.

Four percent of the teeth examined radiographically had associated periapical pathology. Of these, there was a 2:1 ratio of mandibular to maxillary lesions. Overall, 26.0% of the adult male population had at least one lesion (the most severely affected mandible contained five separate lesions). Approximately 56% of teeth with periapical pathology had an attritional score of five or more (Fig. 3).

#### Antemortem tooth loss

Fifty-eight percent of adult males had one or both maxillary central incisors missing. This was a statistically significant finding ( $P < 0.01$ ), indicating that the traditional avulsion of one or both permanent central incisors in males upon their initiation into manhood was responsible for tooth loss rather than disease.

There were only two other cases of antemortem tooth loss involving a maxillary left lateral incisor and a mandibular left third

molar. In the case of the incisor, there was complete healing of the alveolus and mesial drift of the adjacent teeth with partial closure of the gap. The third molar site showed incomplete healing and appeared relatively recent, but with no evidence of local trauma or other indication of the method of loss, such as bone resorption due to periodontal disease.

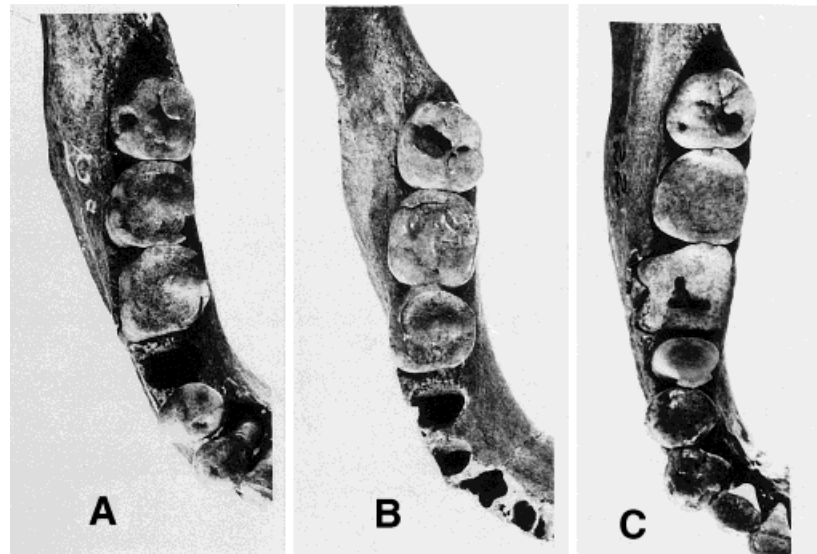
#### Alveolar bone loss

Eighty-seven percent of individuals had either moderate (2–5 mm) or severe (>5 mm) loss of bone from the alveolar crest. The area of greatest loss of alveolar crest height was in the anterior segment (incisors and canines), with more than one half in the severe category. The average loss in the anterior segment was 3.5 mm and 1.7 mm in the posterior segment.

#### Dental caries

Six cases of dental caries (0.8%) were seen in five individuals (Fig. 4). Three lesions were found in maxillary teeth, with two being located on the mesial surfaces of both canines in one maxilla. The third lesion was located in the distal occlusal developmental pit of a right maxillary premolar. All man-

Fig. 4. Caries were found most commonly on the occlusal surface of mandibular third molars. The three cases noted in the Broadbeach group each involved the right mandibular third molar.



dibular tooth lesions were present on the occlusal surfaces of the right third molars and measured up to 6 mm in diameter at the enamel surface. It is noteworthy that this tooth was least affected by occlusal attrition with clear preservation of the developmental pits and fissures. All cases of caries were confirmed by the characteristic appearance on both radiographs and photographs.

#### Other pathology and anomalies

Moderate malocclusion was relatively common among the lower anterior teeth. This manifested as a malalignment with arch-line irregularity and tooth rotation indicative of an arch length deficiency. Only a few individuals showed severe malocclusions with multiple impactions, transposition of teeth, and anterior crowding. Impaction of teeth other than third molars (seen in three cases) was rare, but when this occurred the impactions were multiple. In one young adult, both mandibular third molars and the left mandibular second premolar were impacted and the mandibular anterior teeth were crowded. In addition, the left maxillary canine was transposed to a position distobuccal to the left first premolar.

Mesotaurodontism (Mena, 1971) was observed in the majority of posterior teeth. This occurs when the tooth root furcation is

found in the apical one half of the root trunk complex, but with an apparent normal overall root length (Fig. 5). The pulp chambers were elongated without the dentinal and enamel thickness of the crown and furcation areas being compromised.

Pulp stones were observed in 34.2% of mandibular molars but in only 2.9% of maxillary molars. In the mandible, 53% were found in first molars, 41% in second molars, and 6% in third molars. The distribution of pulp stones between the maxilla and mandible and between the molar teeth positions were statistically significant ( $P < 0.01$ ). This pattern also correlated directly with the degree of attrition.

Excessive secondary dentine formation was found in 11.1% of molar teeth. This secondary dentine almost completely obliterated the pulp chambers, leaving a small space which appeared as an 'X' configuration radiographically (Fig. 6). Accordingly, these pulp chambers were referred to as "cruciate pulp chambers." There was an even distribution of this pattern between the maxillary and mandibular molars; however, the first molars were involved more commonly than the second molars in both the maxilla (2.5:1,  $P < 0.05$ ) and mandible (4.3:1,  $P < 0.01$ ). There were no instances of third molar involvement.



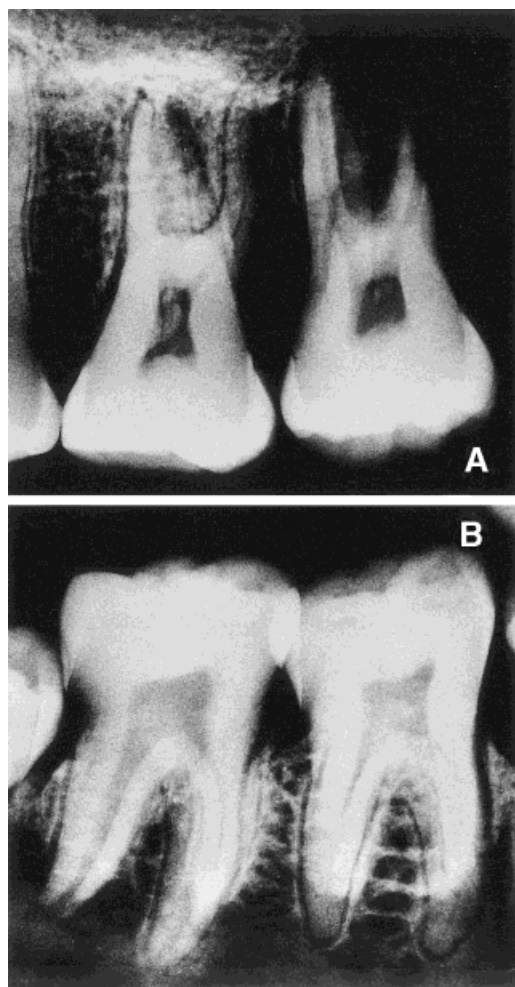


Fig. 5. Mesotaurodontism was noted in over 10% of molars. This radiograph of the left maxillary and mandibular first and second molars shows the elongated pulp chamber and root trunk, particularly obvious in the maxilla.

## DISCUSSION

The pattern and severity of dental attrition in the Broadbeach Aboriginal adult male population indicates that this group was not fully marine-dependent. The attritional scores were within the accepted limits for hunter-gatherer populations who have a significant marine content in their diet, but the values were located toward the lower end of this range (Table 1). In an entirely marine-dependent group the values should be toward the upper end of the range. It

seems likely from the specific wear patterns that a significant amount of the attrition observed in the dental record was due to task activities. The pattern of wear gradients and molar concavities suggest an action of habitual abrasion that could be produced by gripping cord, vine, or sinew between the upper and lower teeth and pulling it through to strip and prepare it for binding material.

Periapical pathology was not related directly to dental caries and subsequent pulpal infection in the generally accepted progression pattern. There were no instances of a carious lesion being associated with periapical pathology. The other reasonable cause for the presence of periapical pathology in the Broadbeach population is the extensive amount of dental wear (Hall et al., 1986; Littleton and Frohlich, 1993). This is supported by the higher attritional scores and incidence of periapical pathology in the mandible, as well as the greater degree of attrition seen in those teeth with periapical pathology. This also supports the premise of a diet based on hunting and gathering.

In the overall dental record, only 33.2% and 38.6% of teeth in the maxilla and mandible, respectively, scored an attritional level of five or greater, yet for those teeth with associated periapical pathology this proportion rose to 55.6%. Furthermore, teeth with periapical pathology showed high rates of pulp stones and cruciate pulp chambers, both of which have been associated with heavy dental wear (Ramfjord and Ash, 1971).

The tradition of avulsing one or both upper central incisors of boys at the age of initiation into adult life is reported in historical accounts and personal journals (Petrie, 1983) and in itself does not represent specific pathology. The degree of alveolar bone loss is consistent with the heavy attrition observed in the dental record. This latter finding further strengthens the proposal of a diet that is composed of marine, hunting, and gathering sources.

The apparent absence of dental caries is attributable to a combination of factors. The inhibitory action of attrition and prehistoric "cleaning" or dental hygiene on caries have both been documented (Hall et al., 1986;



Fig. 6. The phenomenon of "cruciate pulp chambers" was observed in 11.1% of molar teeth.

Brown and Molnar, 1990) and are clearly present in the dental record of the Broadbeach population. Fluoride has a direct inhibitory affect on the development of dental caries, and while there is no evidence to suggest natural fluoride in the local water, fluoride would be gained directly from a marine supplement to the diet (Pu and Lilienthal, 1961). The absence of caries also indicates a high proportion of dietary protein and fat, both of which have a protective effect, and a relative absence of carbohydrates and grain foods, as seen in agricultural populations (Littleton and Frohlich, 1993).

Malocclusion has been associated with soft diets, which fail to promote adequate interdental wear/attrition during the developmental period of the permanent dentition, resulting in insufficient arch length for the eruption of some secondary teeth (Begg, 1965). Notwithstanding the heavy wear both occlusally and interproximally, there was a moderate degree of malocclusion and anterior crowding in the Broadbeach population. Certain teeth of this population, when analysed metrically, were found to be larger than normal (Smith et al., 1981). This may be explained by the presence of taurodontism of the molar teeth, where the pulp chambers are of normal proportions but within an

enlarged root trunk. The presence of malocclusion and crowding in the dental record suggests that the attrition, although heavy, was inadequate to provide sufficient space for the eruption of teeth later in the dental sequence.

### CONCLUSION

The pattern and severity of dental attrition within the Broadbeach adult male population indicates a diet that was not marine-dependent. Periapical pathology caused by wear has been associated with hunter-gatherer populations (Jurmain, 1990). The rate and amount of antemortem tooth loss and alveolar bone loss together with a relatively low incidence of caries (Table 1) provide evidence to support a hunting and gathering diet with a significant marine contribution.

This study has differentiated the importance of marine and terrestrial food in the diet of the Broadbeach Aboriginal population based on the specific patterns of dental pathology. These findings are supported by both historical accounts and the archaeological analysis of the original excavation site.

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TABLE 1. Adapted table of dietary related pathology among comparative populations

	Sample size	Attrition <sup>1</sup>			Caries		Cyst formation		Antemortem tooth loss	
		Incisor/ canines	Premolars	Molars	%	n	%	n	%	n
Marine-dependent diet										
Ras El Hamra <sup>2</sup>	49		12.3% Severe 60.7% Moderate		0.00	600	Multiple	600	Low-nil	600
Coastal SW Cape <sup>3</sup> (-13 ≤ δ <sup>13</sup> C ≤ -10)	18	6	4	3	0.00	309	—	—	—	—
Hunting and gathering diet										
Oakhurst <sup>3</sup>	48	6	5	3	17.7	192	—	—	—	—
Coastal SW Cape <sup>3</sup> (-18 ≤ δ <sup>13</sup> C ≤ -15)	13	4	3	3	4.4	249	—	—	—	—
CA-Ala-329 <sup>4</sup>	195	5.71	5.71	5.59	0.57	—	39 Individuals	107	—	—
Mixed economy diet (pastoralism, fishing, and agriculture)										
Umm An-Nar <sup>2</sup>	108	5	3	2	2.4	327	5.9	779	9.6	779
Bronze Age Shimal <sup>2</sup>	26	4	2	2	4.6	43	—	—	35.1	110
Iron Age Galilah <sup>2</sup>	53	3	2	1	1.2	261	—	—	35.3	167
Failaka <sup>2</sup>	9	—	—	—	5.3	207	3.9	207	1.9	207
Mixed farming diet										
Islamic Bahrain <sup>2</sup>	38	2	2	2	14	471	5.3	626	20.8	626
Iron Age Maysar <sup>2</sup>	50		Slight/moderate		—	—	—	—	—	—
Faraoskop <sup>3</sup>	16	6/7	4	9	8.7	138	—	—	—	—
Intensive gardening diet										
Bronze Age Bahrain <sup>2</sup>	75		11.4% Moderate <sup>5</sup>		13.3	308	2.1	928	31	928
Iron Age Bahrain <sup>2</sup>	129		25% Moderate <sup>5</sup>		17.2	495	5.2	834	36.1	834
Ras-al-Khaimah <sup>3,2</sup>	6		Light/moderate		1.2	31	3	34	36.4	34
Ras-al-Khaimah <sup>5,2</sup>	8+		Light		25	28	2.3	112	27.6	112
Broadbeach Aboriginal	36	3.8	3.4	4.4	0.8	660	5.0	1120	0.1	1,120
Burial ground sample			21.2% Severe 34.9% Moderate				26 Individuals	36		

<sup>1</sup> Molnar, 1971.<sup>2</sup> Littleton and Frohlich, 1993.<sup>3</sup> Sealy et al., 1992.<sup>4</sup> Jurmain, 1990.<sup>5</sup> Pronounced to extreme attrition on the anterior teeth and slight on the posterior teeth.

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